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(54) **Compensator for earth boring bits.**

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US-A- 3 370 659
US-A- 3 476 195
US-A- 3 719 241
US-A- 3 847 234
US-A- 3 995 367
US-A- 4 055 225
US-A- 4 073 548

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Description

This invention relates in general to earth boring bits but in particular to improvements in their lubricant pressure compensators and relief means.

Earth boring bits of the rolling cutter type have sealed bearings and lubrication systems that include pressure compensation and relief means to minimize the pressure differential across the seals that separate the lubricant from the drilling mud in a bore hole.

A successful seal means is disclosed in US-A-3,397,928. A successful pressure compensation and relief means is disclosed in US-A- 4,055,225 which forms the basis for the preamble of claim 1. Other systems include the use of the original commercially successful pressure relief valve disclosed in US-A-3,476,195 and the use of a pinhole or slit in a flexible compensator or diaphragm that permits liquid flow either into or from the compensator cavity, as disclosed in US-A- 3,847,234. Examples of known lubrication systems for sealed bearing rock bits are shown in US-A- 3 995 367 and US- 3 719 241.

The failure of any element in the lubrication system of a bit eventually, but usually soon, concludes its useful life. Too often, a life determinative failure occurs in either the diaphragm or the relief means. Varying stresses caused by the lubricant pressure variations in a bit, along with increased temperatures downhole, accelerate compensator failure, especially those which include metal components bonded to rubber.

It is the general object of the invention to provide an improved pressure compensating and relief system in an earth boring bit.

This object is achieved in a pressure compensating and relief system for use in an earth boring bit having a rotatable cutter secured to a bearing shaft on a head, comprising

seal means between the cutter and the bearing shaft;

the head including a lubricant passage extending between the bearing shaft and a compensator cavity:

the compensator cavity having one end exposed, by means of a mud passage, to mud in a borehole during drilling;

a flexible diaphragm having a periphery sealingly secured in the compensator cavity to form a mud region and a lubricant region - and to induce upon the lubricant the hydrostatic pressure of the mud in a borehole; and

a wall at the end of the compensator cavity surrounding the mud passage

a central portion of the diaphragm having a perforated protrusion extending into the mud region to form a self energizing configuration exposed to the mud region that seals the perforation when the pressure of the lubricant is less than or substantially equal that of the mud;

said wall at the end of the compensator cavity surrounding the mud passage engaging an area around the protrusion when the diaphragm is extended by lubricant pressure build-up that exceeds the mud pressure;

whereby the resulting pressure build-up opens the perforation to release lubricant.

Advanteageous embodiments of the invention are claimed in the dependent claims.

The improved compensator has a flexible diaphragm in a compensator cavity that minimizes tensile stresses in the diaphragm. Metal components are not used in the diaphragm to avoid the failures that occur in the bonded region between metal and rubber.

The flexible diaphragm has a perforated protrusion extending into the drilling mud region. The perforation is self energizing and seals when the pressure of the lubricant is less than or substantially equal to that of the mud that surrounds the bit during drilling. A wall at the end of a compensator cavity in the bit body contains a mud passage and engages an area of the compensator around the protrusion when the diaphragm is fully extended by lubricant pressure build-up that exceeds the hydrostatic pressure of the mud. This minimizes tensile stresses in the diaphragm. The resulting pressure differential opens the perforation, releases lubricant and relieves the build-up of lubricant pressure. The protrusion may have a larger surface area in the mud region than in the lubricant region. In such an embodiment the exterior or mud side of the protrusion is cylindrical and a beveled entrance to the perforation is used on the lubricant side of the diaphragm. The protrusion ideally may have an annular reinforcing ridge to confine the ends of the perforation, which is usually a slit. Further, the diaphragm may have a periphery enlarged to accommodate an integral o-ring that is compressed between captive, preferably beveled surfaces on a compensator protector cup and the compensator cavity. The end of the diaphragm may have clearance from the end of the compensator cavity and clearance from the end of the protector cup when fully extended but unstressed. This centers the protrusion when fully extended in either direction.

The above as well as additional objects, features, and advantages of the invention will become apparent in the following description in combination with de attached drawings, wherein:

Figure 1 is a perspective view, partially in longitudinal section, of an earth boring bit of the rolling cutter type having a lubricant compensator and pressure relief system constructed in accordance with the principles of the invention;

Figure 2 is an enlarged, fragmentary longitudinal section of the lubricant compensator and pressure relief system shown in Figure 1, showing the diaphragm filled with grease;

Figure 3 is an enlarged, fragmentary longitudinal section, similar to that of Figure 2, except the grease in the compensator has been expended and drilling mud has essentially filled the compensator; and

Figure 4 is a perspective view of the flexible diaphragm of Figs. 1 and 2.

The numeral 11 in the drawing designates an earth boring bit which consists of three identical head sections 13, each of which supports a rotatable cutter 15 having a plurality of earth disintegrating teeth 17, here depicted as being inserts of sintered tungsten carbide.

Thus, the three head sections 13 together form a head or body having a hollow interior 19 which terminates at the lower end in usually three passages, each containing a nozzle 21 used to direct drilling fluid or mud against the borehole bottom (not shown).

A lubricant passage 23 in each head section extends between the bearing means 25 of a cantilevered bearing shaft 26 and a lubricant pressure compensator and relief means 27.

Lubricant is maintained in the bearing means 25 by a seal means 29, here an o-ring as shown in the previously mentioned US-A- 3,397,928. Each rotatable cutter 15 is retained to the bearing shaft 26 by suitable means such as the snap ring, as disclosed in US-A- 4,491,428.

As shown in Fig. 2, a lubricant compensator and relief means 27 is positioned or formed in each of the head sections 13. A mud passage 41 leads to an interior body or wall surface 39 (see Fig. 1) on the interior of the bit above the rotatable cutters 15. An interior wall or shoulder 43 forms the lower part of a compensator cavity 45 which has a lower region 47 of one diameter and an upper region 49 of a larger diameter. A recess 51 contains an o-ring 52 in a groove or gland 53 and includes a snap ring 54 in a recess 55 is used to retain a compensator cap 77.

The lower region 47 of the compensator cavity 45 as shown in Fig. 2 contains a flexible diaphragm 57 that has a central portion 59 perforated at 61 and beveled at 62. The perforation 61 is actually a slit starting in a recess 64 having ends limited by an annular ridge 66. The periphery 63 of the diaphragm 57 is in the form of an o-ring shaped annular area that is compressed between an inverted incline or lip 65 in the cavity upper region 49 and an opposed downwardly facing beveled portion or shoulder 67 on the lower extremity of a protector cup 69. This cup has an aperture 71 in its upper portion 73, through which grease communicates with the lubricant passage 23.

The protector cup 69 is biased downwardly by a lower surface 75 in a compensator cap 77, which has a passage 79 through which lubricant is forced prior to insertion of a pressure seal pipe plug 81. An arcuate groove 83 permits lubricant flow freely between the passage 23 in the head section 13, around the exterior surface 85 of the protector cup 69, and to or from the interior volume 87 (defined by the interior surfaces 89 of the protector cup 69 and an interior surface 91 of the flexible diaphragm 57).

Upon assembly and in operation, the flexible diaphragm 57 has its periphery 63 compressed (indicated by the dotted lines) and is sealingly secured in the compensator cavity between surfaces 65, 67 to form a mud region 93 and a lubricant volume or region 87. The central portion 59 of the flexible diaphragm 57 has a perforation 61 and extends into passage 41 of mud region 93 when fully expanded to form a self energizing area, exposed to the drilling mud, that seals the perforation when the pressure of the lubricant is less than or substantially equal to that of the mud.

The wall or shoulder 43 at the lower end of the compensator cavity around the mud passage 41 engages the flexible diaphragm when fully extended by lubricant pressure build-up that exceeds the hydrostatic pressure of the drilling mud. Thus, the resulting pressure differential opens the perforation 61, releases the lubricant and relieves the build-up of lubricant pressure inside the lubricant volume 87.

The diaphragm is preferably constructed of nitrile rubber and the perforation is sized along with the configuration of central portion 59, such that it will open at a selected pressure not less than substantially fifty psi (344,75 kPa).

This self energizing effect is achieved in the preferred embodiment by utilizing a protrusion having an area exposed to the mud that is greater than the area exposed to the lubricant such that sealing of the perforation is effected for all mud pressures greater than the lubricant pressure. Preferably, the protrusion is cylindrical, with a radius joining the exterior surface of the flexible diaphragm 57, as indicated in Figure 2.

The width of perforation or slit 61 is determined by the diameter of the annular ridge 66. Its length or depth is determined by the thickness of the diaphragm, the depth of bevel 62 and the height of central portion or appendage 59. All of these features determine the differential pressure at which the slit 61 is energized to release lubricant.

Another feature of the invention are the clearances D_1 (see Fig. 2) and D_2 (see Fig. 3). These clearances occur when the flexible diaphragm is completely filled with lubricant (Fig.2) or inverted

by drilling mud (Fig. 3), but before the rubber is stretched. This self-centers the central portion or appendage 59 with respect to mud passage 41 (Fig. 2) and aperture 71 (Fig. 3). Otherwise, a relatively thin wall section of the diaphragm may align with either mud passage 41 or aperture 71 and a large pressure differential may rupture the diaphragm.

It is advantageous that the flexible diaphragm 57 is connected without bonding to the compensator cavity 45 by the compression of its periphery 63 between the surface 65 and the beveled portion 67 of the protector cup. Separation and failure of diaphragms or compensators have been observed when metal/rubber bonding is used. Such constructions may cause excessive stress in the rubber at the bonded areas during pressure build-up in the lubricant. Further, the use of a shoulder 43 in the compensator cavity 45 to engage the end of the perforated diaphragm minimizes stresses and enhances reliability. Additionally, the upper portion 73 and the opening 71 of protector cup 69 are designed to form a backup support for the central portion 59 of flexible diaphragm 57 so that when substantially higher mud pressure than lubricant pressure exists no damage will occur to the diaphragm.

Claims

1. A pressure compensating and relief system for use in an earth boring bit having a rotatable cutter (15) secured to a bearing shaft on a head (13), the system comprising;

seal means (29) between the cutter (15) and the bearing shaft;

the head (13) including a lubricant passage (23) extending between the bearing shaft and a compensator cavity (45);

the compensator cavity (45) having one end exposed, by means of a mud passage (41), to mud in a borehole during drilling;

a flexible diaphragm (57) having a periphery (63) sealingly secured in the compensator cavity (45) to form a mud region (93) and a lubricant region (49) - and to induce upon the lubricant the hydrostatic pressure of the mud in a borehole; and

a shoulder (43) at the end of the compensator cavity (45) surrounding the mud passage (41);

characterized by:

a central portion (59) of the diaphragm (57) having a perforated protrusion (59) extending into the mud region to form a self energizing configuration exposed to the mud region (93) that seals the perforation (61) of the protrusion (59) when the pressure of the lubricant is less than or substantially equal that of the mud;

said shoulder (43) at the end of the compensator cavity surrounding the mud passage engaging an area around the protrusion (59) when the diaphragm (57) is extended by lubricant pressure build-up that exceeds the mud pressure;

whereby the resulting pressure build-up opens the perforation to release lubricant.

2. The pressure compensating and relief system as in claim 1, wherein said perforated protrusion extending into the mud region forms a larger area of diaphragm around the perforation in the mud region than in the lubricant region to create a self energizing effect in said configuration that seals the perforation when the pressure of the lubricant is less than or substantially equal that of the mud.

3. The pressure compensating and relief system as in claim 2, wherein said perforated protrusion (59) extending into the mud region has a beveled entry (62) to the perforation exposed to the lubricant region.

4. The pressure compensating and relief system as in anyone of the claims 1 to 3, which further comprises an exclusively rubber diaphragm (57) with an enlarged peripheral portion (63) and a rigid protector cup (69) biased against and compressing the peripheral portion.

5. The pressure compensating and relief system as in claim 4, wherein the end of the diaphragm (57) has clearance (D1) from the end of the compensator cavity and clearance (D2) from the end of the protector cup (69) when fully extended but unstressed.

Patentansprüche

1. Druckkompensier- und -begrenzungssystem zur Verwendung in einem Erdbohrmeißel, der ein drehbares Schneidwerkzeug (15) hat, das auf einer Lagerachse an einem Kopf (13) befestigt ist,
wobei das System aufweist:
eine Dichteinrichtung (29) zwischen dem Schneidwerkzeug (15) und der Lagerachse;
den Kopf (13), der einen Schmiermitteldurchlaß (23) aufweist, welcher sich zwischen der Lagerachse und einem Kompensatorhohlraum (45) erstreckt;
den Kompensatorhohlraum (45), von welchem ein Ende mittels eines Schlammdurchlasses (41) mit Schlamm in einem Bohrloch während des Bohrens beaufschlagt ist;

eine flexible Membran (57), die einen Umfang (63) hat, der in dem Kompensatorhohlraum (45) abdichtend befestigt ist, um ein Schlammgebiet (93) und ein Schmiermittelgebiet (49) zu bilden und um auf das Schmiermittel den hydrostatischen Druck des Schlamms in einem Bohrloch auszuüben; und
eine Schulter (43) an dem Ende des Kompensatorhohlraums (45), welche den Schlammdurchlaß (41) umgibt;
gekennzeichnet durch:
einen zentralen Teil (59) der Membran (57), der einen perforierten Vorsprung (59) hat, welcher sich in das Schlammgebiet erstreckt, um eine sich selbstbetätigende Konfiguration zu bilden, die dem Schlammgebiet (93) ausgesetzt ist und die Perforation (61) des Vorsprungs (59) verschließt, wenn der Druck des Schmiermittels kleiner als der oder im wesentlichen gleich dem des Schlammes ist;
wobei die Schulter (43) an dem Ende des Kompensatorhohlraums, die den Schlammdurchlaß umgibt, einen Bereich um den Vorsprung (59) erfaßt, wenn die Membran (57) durch Schmiermitteldruckaufbau, welcher den Schlammdruck übersteigt, ausgefahren ist;
wodurch der resultierende Druckaufbau die Perforation öffnet, um Schmiermittel freizusetzen.

2. Druckkompensier- und -begrenzungssystem nach Anspruch 1, wobei der perforierte Vorsprung, der sich in das Schlammgebiet erstreckt, einen größeren Bereich der Membran um die Perforation in dem Schlammgebiet bildet als in dem Schmiermittelgebiet, um einen Selbstbetätigungseffekt in dieser Konfiguration zu erzeugen, durch den die Perforation verschlossen wird, wenn der Druck des Schmiermittels kleiner als der oder im wesentlichen gleich dem des Schlammes ist.

3. Druckkompensier- und -begrenzungssystem nach Anspruch 2, wobei der perforierte Vorsprung (59), der sich in das Schlammgebiet erstreckt, einen abgeschrägten Eingang (62) an der Perforation hat, der dem Schmiermittelgebiet ausgesetzt ist.

4. Druckkompensier- und -begrenzungssystem nach einem der Ansprüche 1 bis 3, welches weiter eine ausschließlich aus Gummi bestehende Membran (57) mit einem vergrößerten Umfangsteil (63) und einem starren Schutzbecher (69) aufweist, der gegen den Umfangsteil vorgespannt und an diesem zusammengedrückt ist.

5. Druckkompensier- und -begrenzungssystem nach Anspruch 4, wobei das Ende der Membran (57) einen Abstand (D_1) von dem Ende des Kompensatorhohlraums und einen Abstand (D_2) von dem Ende des Schutzbechers (69) hat, wenn sie vollständig ausgefahren, aber unbeansprucht ist.

Revendications

1. Système de compensation de pression et de décharge de pression pour utilisation dans un trépan pour forage du sol ayant un tranchant tournant (15) fixé à un arbre de support sur une tête (13), le système comprenant :
un moyen de joint (29) entre le tranchant et l'arbre de support ;
la tête (13) comportant un passage de lubrifiant (23) se prolongeant entre l'arbre de support et une cavité de compensateur (45) ;
la cavité de compensateur (45) ayant une première extrémité exposée, au moyen d'un passage de boue de forage (41) à la boue de forage dans un trou de forage pendant le forage ;
un diaphragme souple (57) comportant une périphérie (63) fixée de manière étanche (93) dans la cavité de compensateur (45) pour former une région de boue de forage et une région de lubrifiant (49) et pour induire sur le lubrifiant la pression hydrostatique de la boue de forage dans un trou de forage ; et
un épaulement (43) à l'extrémité de la cavité de compensateur (45) entourant le passage de boue de forage (41) ;
caractérisé en ce que
une partie centrale (59) du diaphragme (57) comporte une saillie perforée (59) se prolongeant dans la région de boue de forage pour former une configuration se renforçant par elle-même exposée à la région de boue de forage (93) qui obture la perforation (61) de la saillie (59) lorsque la pression du lubrifiant est inférieure ou pratiquement égale à celle de la boue de forage ;
ledit épaulement (43) à l'extrémité de la cavité de compensateur entourant le passage de boue de forage engagea une zone autour de la saillie (59) lorsque le diaphragme (57) est dilaté par la remontée de la pression du lubrifiant qui dépasse la pression de la boue de forage ;
d'où il résulte que la remontée de la pression obtenue ouvre la perforation pour libérer le lubrifiant.

2. Système de compensation de pression et de décharge de pression selon la revendication 1,

dans lequel la saillie perforée se prolongeant dans la région de boue de forage forme une région plus grande du diaphragme autour de la perforation dans la région de boue de forage que dans la région de lubrifiant pour créer un effet d'autorenforcement dans ladite configuration qui obture la perforation lorsque la pression du lubrifiant est inférieure ou pratiquement égale à celle de la boue de forage.

3. Système de compensation de pression et de décharge de pression selon la revendication 2, dans lequel

la saillie perforée (59) se prolongeant dans la région de boue de forage présente une entrée conique (62) à la perforation exposée à la région de lubrification.

4. Système de compensation de pression et de décharge de pression selon l'une quelconque des revendications 1 à 3, qui comporte de plus un diaphragme exclusivement en caoutchouc (57) avec une partie périphérique élargie (63) et une coupelle de protection rigide (59) sollicitée contre et comprimant la partie périphérique.

5. Système de compensation de pression et de décharge de pression selon la revendication 4, dans lequel l'extrémité du diaphragme (57) comporte une séparation (D1) depuis l'extrémité de la cavité de compensateur et une séparation (D2) depuis l'extrémité de la coupelle de protection (69) lorsque totalement dilatée mais pas contrainte.

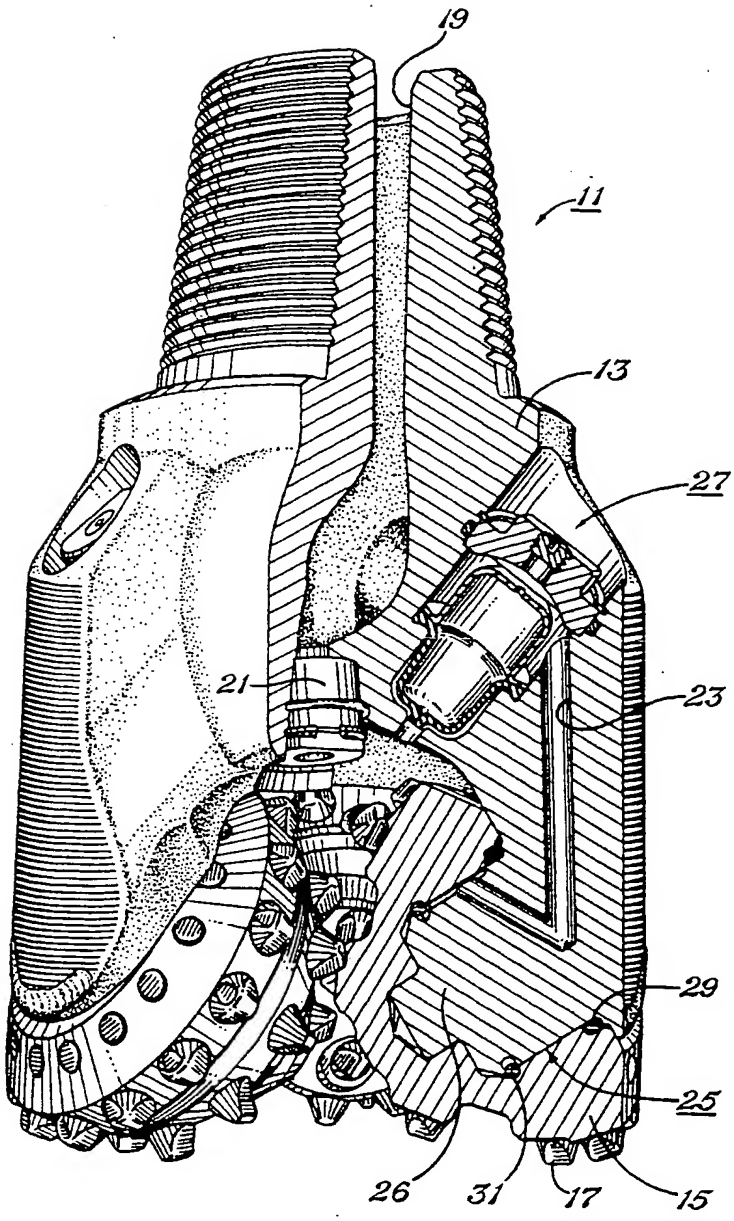

Fig. 1

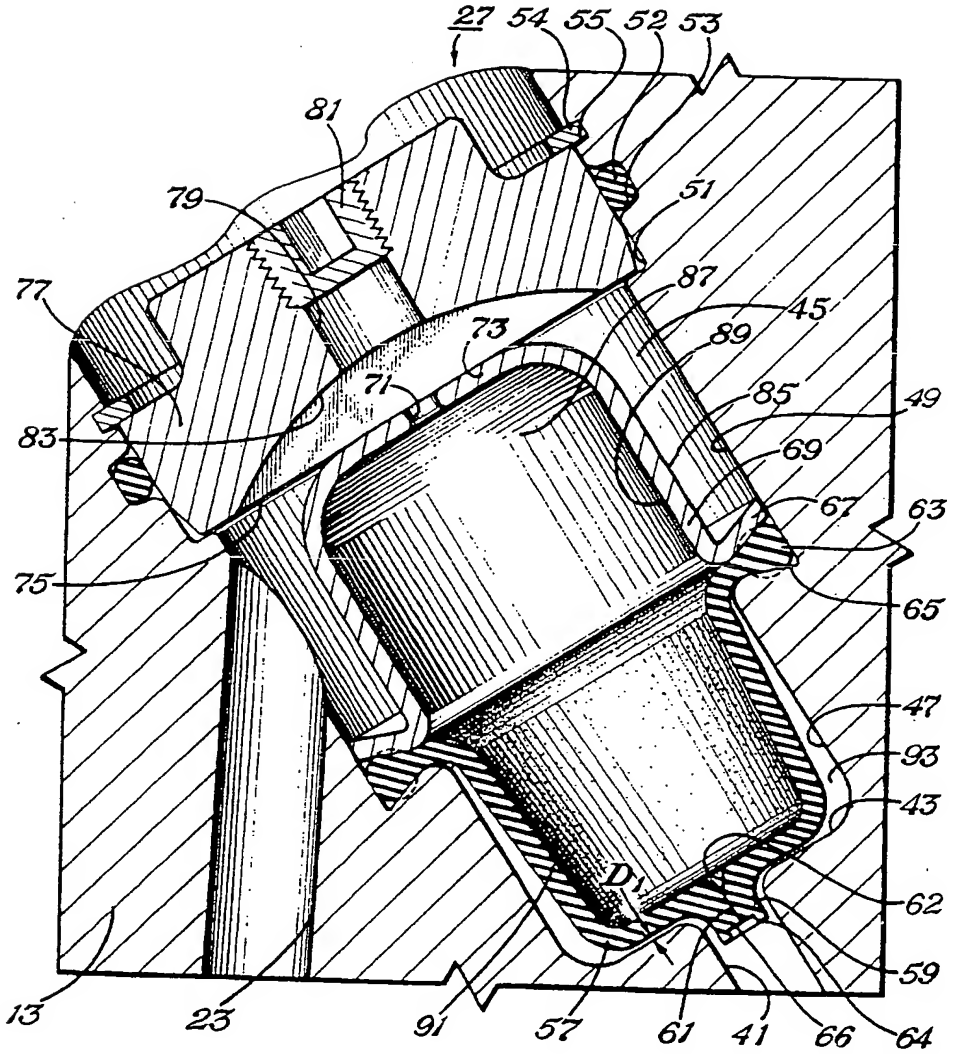
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Fig. 2

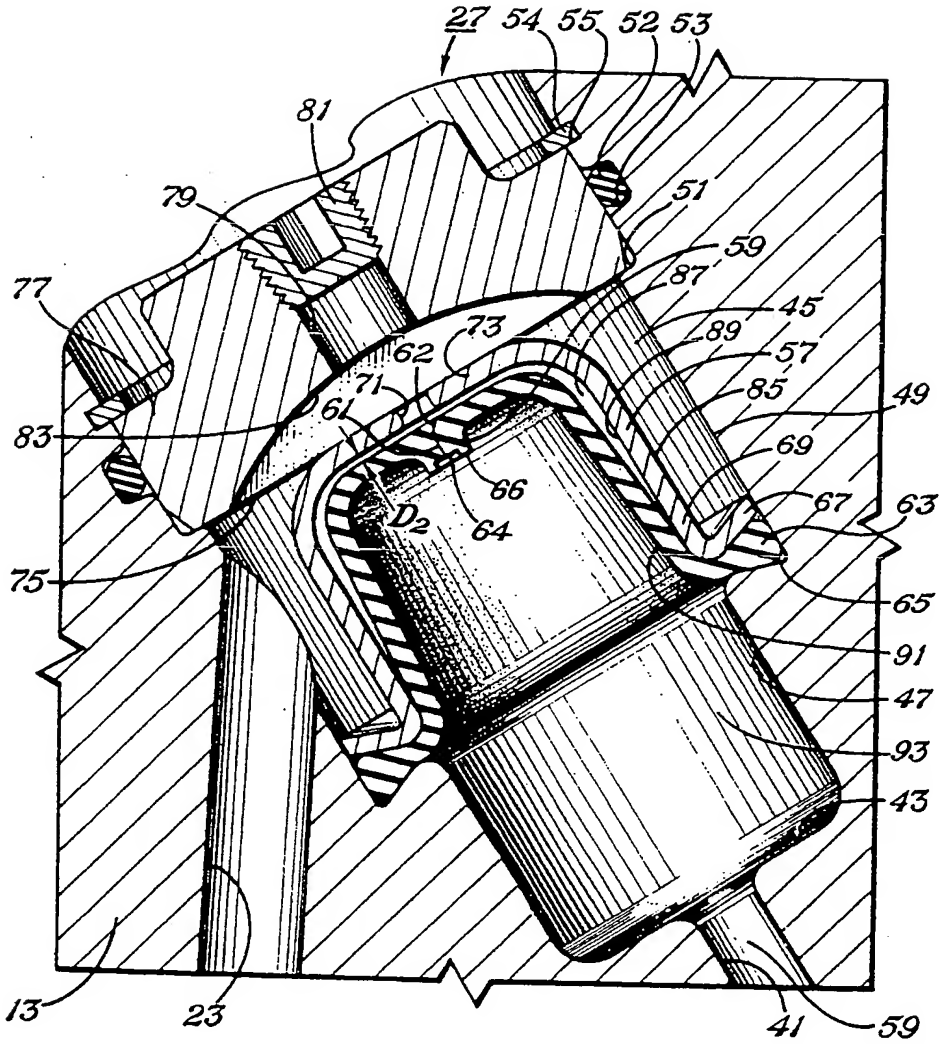
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Fig. 3

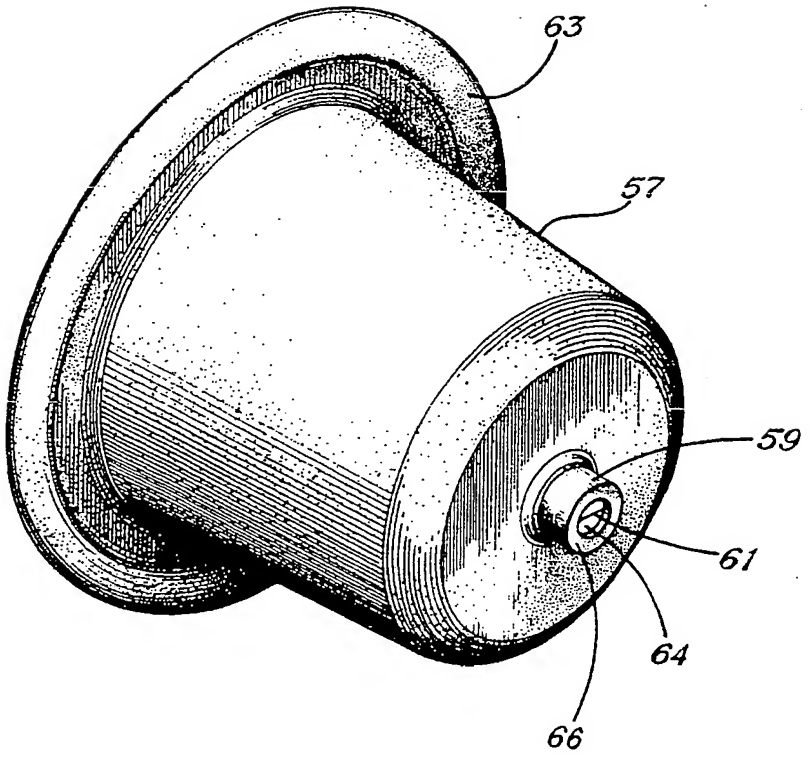

Fig. 4